Development of Online Report Delivery Management System By E-Med

Abstract—**In this study, we propose an innovative solution to enhance Electronic Health Records (EHR) and Electronic Medical Records (EMR) systems by automating clinical workflows. Utilizing biometric identification for patient recognition, our system comprises two modules: E-Med Uploader and E-Med Patient. The E-Med Uploader automates the identification and uploading of patient reports to a centralized server, while the E-Med Patient app provides patients with access to and insights into their medical reports. To address time and resource constraints, certain features such as Doctor Appointment scheduling, Real-time Doctor-Patient Communication, Doctor Assistant, Hospital Information System (HIS), Payment Integration Module, and Patient Companion have been temporarily omitted, allowing for potential future implementation and system refinement.**

Keywords: Electronic Health Record (EHR) software, Electronic Medical Record (EMR) software, Online Report Delivery System, Clinical Workflows, Biometric Identification

I. INTRODUCTION

Telehealth employs electronic communication for remote health services, addressing barriers like rural isolation and transportation challenges. It enhances patient-doctor interactions, monitoring, and access to care in underserved areas [1]. Telehealth spans distance learning, expert consultations, robotic surgeries, remote monitoring, and online patient-doctor interactions, fostering versatile healthcare delivery and accessibility [2]. A healthcare system is a network of individuals, organizations, and resources organized to provide medical services, addressing the health needs of specific populations [3].

Globally, healthcare systems adapt to unique country needs, featuring common elements like primary care and public health. Planning approaches range from market involvement to coordinated efforts, emphasizing evolutionary rather than revolutionary changes [4] . Healthcare providers, whether self-employed or working in diverse institutions, encompass a range of professionals from physicians to psychologists, nurses, pharmacists, and allied health workers, offering various medical services [5]. "Medical record," "health record," and "medical summary" are often used interchangeably, referring to the systematic documentation of an individual patient's medical history and care within a specific healthcare provider's jurisdiction over time [6].The medical record logs healthcare professionals' observations, treatments, medication orders, and test results. Its accurate maintenance is a healthcare provider requirement, often mandated for licensing or certification [7].The terms encompass paper, physical, and digital records for each patient. Traditionally managed by healthcare providers, online advancements have led to patient-maintained records on external websites, supported by US national health entities and AHIMA,the American Health Information Management Association [8]..

II. LITERATURE REVIEW

A. *Problem Statement:*

The patient-doctor relationship begins with non-verbal cues, influencing perceptions and interactions. This study explores patients' experiences with doctors' waiting areas and practices, finding a correlation between the clinic's interior design and patients' trust and intimacy. The paper discusses findings, recommendations, limitations, and suggestions for future research based on quantitative analysis of 95 respondents in the mental health division.

B. *Hypothesis:*

The proposed system involves a biometric identification system for individuals with user roles based on validation. Access to personal history is limited to authorized persons. The data is secured using block chain technology. The hardware component aims to streamline patient identification across hospitals, with version control software and scripts managing report generation and database updates. Plans include updating a cross-platform application with a personalized character, 3D rigging, and natural language processing for interactive communication.

The project requires the following resources:

- Unique Identification System (Identifier):
    1. Hardware: Devices for biometric identification.
    2. Software: System software for unique identification.
- Background Service App for Windows (Uploader):

An application that runs in the background for uploading generated reports to the central server.

- Data Presenter App for Windows and Android (Presenter):
    1. Application for both doctors and patients.
    2. Features may vary based on user roles.
    3. Doctor features include real-time notifications for critical reports and access to prescriptions.
    4. Patient features include access to their complete medical data.
    5. Future integration with neural networks, machine learning algorithms, and tools like Tensor Flow and Google Cloud AI for treatment suggestions.

C. *Biometric Identification System:*

Biometrics is a validation method utilizing biological characteristics, as Rothenberg defines it as the statistical analysis of such features. Dating back to 500 B.C., fingerprints served as signatures on Babylonian clay tablets. In 1858, the first systematic hand image was captured, and later, Galton, Henry, and Faulds established fingerprints for personal identification. In the U.S. market, fingerprint scanners dominate with a 48.8% share, indicating their prevalence and increasing demand over other biometric methods. [10].

D. *Barcode Scanning Technology:*

Barcode technology is a critical component of Automatic Identification and Data Capture (AIDC). Two categories exist: one-dimensional, altering parallel line widths, and two-dimensional, a graphical image storing data horizontally and vertically. QR codes, a popular two-dimensional type, have advantages like high data capacity, error correction, and versatility. QR code recognition involves image preprocessing and extraction stages. Despite past advancements, challenges persist, such as non-uniform backgrounds affecting decoding. This paper proposes enhanced preprocessing techniques, including modified local thresholding for binarization and efficient QR code extraction using position detection patterns, aiming to address these challenges and improve decoding accuracy [11].

E. *Integrate the Hardware:*

We have used 2 modalities to make an E-Med uploader. Those are a. Fingerprint Scanner (ZkTECO live 20R/SLK20R) and b. 2D Barcode Scanner / Imager (Zebra Digital Scanner DS2208). The website and SDK URL is given below,

- Driver link (GitHub): https://github.com/afmjoaa/E-Med-Uploader-Drivers
- ZkTECO SLK20R Website: https://www.zkteco.com/en/product_detail/SLK20R.html
- Zebra Digital Scanner DS2208 Website:

  https://www.zebra.com/us/en/products/scanners/general-purpose-scanners/handheld/ds2200-series.html

III. METHODOLOGY

A. *Identification of current Problems::*

Challenges in Bangladesh's healthcare system include the absence of a generalized medical report and patient history management service, requiring manual efforts for data labeling. There is no biometric identification system, central patient database, or authorized static data provider. Patients face difficulty switching hospitals and obtaining foreign suggestions. Awareness about preventive diseases is low, and there's a need for an effective doctor assistant program and a generalized online doctor appointment and prescription system.

B. *Proposed Solutions:*

The proposed system involves an automated report delivery system upon full payment, with plugins for online patient, doctor, and hospital registration. Real-time appointments and video call communication between doctors and patients are facilitated. Reports are delivered instantly to associated parties. Each patient is uniquely identified through phone, email, NID number, or fingerprint. The system incorporates automated labeling, easing manual labor. It enables foreign treatment suggestions, offers a doctor assistance system, and includes an online prescription system for comprehensive healthcare services.

The proposed solution entails interconnected modules dependent on a specific order. Due to time and budget constraints, the thesis will primarily focus on developing the automated report delivery system, prioritizing its completion within the given scope...

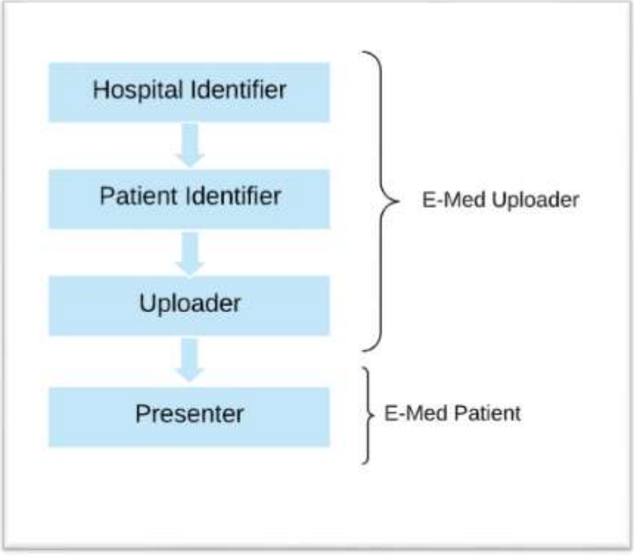

Figure 3.4: *Block diagram of E-Med Automated Report Delivery System*

C. *Selections of the Platforms:*

As in the current scope, we are making 2 apps, they are.

- **E-Med Uploader:** E-Med Uploader is an online report delivery system, it collects all your medical reports from our partner hospitals and stores them to your personal E-Med database. It follows all medical ethical conducts and ensures that your info is secured and only delivered to the doctors you have permitted to.
- **E-Med Patient:** E-med Patient is the patient companion part of our system. Here a patient can connect with the doctor he is in need and discuss his/her problem. With the proper audio-visual connectivity, the patient can also provide his vital physiological info along with all other medical reports from the comfort of his/her home.

We have researched the following platforms to find the suitable one for each one,

- WPF (windows): Windows Presentation Foundation (WPF) is a UI framework in the .NET platform, facilitating the creation of desktop applications. It offers a comprehensive set of development features, including controls, graphics, layout, data binding, and security. Utilizing Extensible Application Markup Language (XAML), it provides a familiar programming experience for .NET developers [12].
- Flutter (cross-platform): Flutter, an open-source UI development kit by Google, is designed for building applications across platforms like Android, iOS, Windows, Mac, Linux, Google Fuchsia, and the web. Originally codenamed "Sky," it debuted in 2015 and

aimed for consistent rendering at 120 frames per second. Flutter 1.0, the stable version, was released on December 4, 2018, marking a significant milestone. Flutter 1.12, released on December 11, 2019, positioned Flutter as the first UI platform for ambient computing [13].

- PyQt: PyQt is a Python binding for the cross-platform GUI toolkit Qt. Developed by Riverbank Computing, it is free software available under licenses like GPL and commercial licenses. Supporting Windows, and UNIX (Linux, macOS), it implements numerous classes and functions, including GUI widgets, database access, rich text editing, XML parsing, SVG support, and more. SIP, developed by Phil Thompson, is used to automatically generate these bindings. In 2009, Nokia released PySide with similar functionality under the LGPL license after disputes over licensing terms with Riverbank Computing [14].
- Native mobile: A native application is specifically designed for a single platform, such as Android or iOS, using the respective coding languages like Objective-C or Swift for iOS and Java or Kotlin for Android. Developed within platform-specific development environments, native apps adhere to the OS's technical and user experience guidelines, providing a consistent look and feel with other native applications on the device. This facilitates quicker user adoption and allows seamless access to the device's built-in capabilities[15].
- Web: Websites or Progressive web app are other options which can be utilized.

After thorough exploration, the decision is to develop the E-Med uploader using WPF. This choice is influenced by the prevalence of Windows PCs in medical modalities and pathology central servers, compatibility with specific hardware SDKs (e.g., fingerprint and barcode scanners) written in WPF (C#), and the widespread use of Windows PCs in hospitals.

On the other hand, the E-Med presenter will be developed with Flutter due to its cross-platform nature. With a single codebase, Flutter can support web, mobile, and desktop platforms simultaneously, making it a versatile choice for reaching a broader audience.

Choosing Flutter for the E-Med presenter ensures a cross-platform dashboard accessible on Windows, Linux, Mac OS, Android, iOS, and the web. However, due to personal proficiency and preference, native Android development is favored for implementation, offering efficiency and familiarity with the chosen technology.

D. Making Prototype and Design:

In this step, we design the prototype. For making the user interface prototype, we explored Sketch and Adobe XD. A short description of them is given below.

- Adobe XD: It is a prototyping application that integrates lightweight design and drawing tools with easy artboard linking for app or website navigation simulation. The results can be quickly shared online as interactive presentations. While resembling a wire framing app, XD is more user-friendly than Illustrator or Photoshop, offering efficiency due to its purpose-built design[16]. It is comparable to Sketch, featuring a vector-based design and a familiar Adobe interface [17].
- Sketch: Sketch is a vector graphics editor created by Bohemian Coding, initially released on September 7, 2010, for macOS. It earned an Apple Design Award in 2012. Notably, Sketch differs from other vector graphics editors as it excludes print design features from its capabilities

After exploring we find Adobe XD more suitable for our needs. As it is free and easy for both design and prototyping.

E. Make working UI specific to the platform:

For making the E-Med uploader we use Visual Studio and ReSharper plugin as IDE. And as it uses XAML (extensile Application Markup Language) for building UI so do we. For making an E-Med presenter we used Android Studio as IDE. And as it uses XML (extensible Markup Language) for building UI so do we. In this app, we tried to decode NID barcode by taking images and we found success to some extent but that’s not that reliable so we used OCR.

Link to the NID PDF-417 barcode decodes GitHub project: https://github.com/afmjoaa/NID_Scanner.

F. Make the flowchart for the uploader & and presenter app:

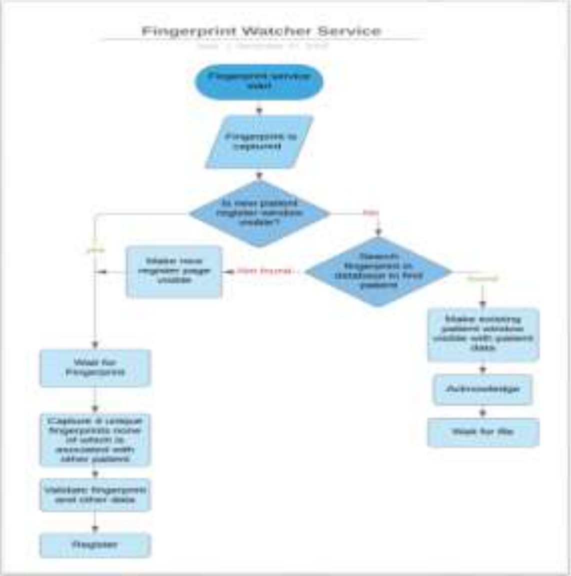
Fingerprint Watcher Service
Fingerprint service start
Fingerprint is captured
Is new patient register window visible?
Search fingerprint in database to find patient
Make new register page visible
Not found
Make existing patient window visible with patient data
Acknowledge
Wait for file
Wait for Fingerprint
Capture 4 unique fingerprints none of which is associated with other patient
Validate fingerprint and other data
Register

Figure 3.18: Fingerprint watcher service

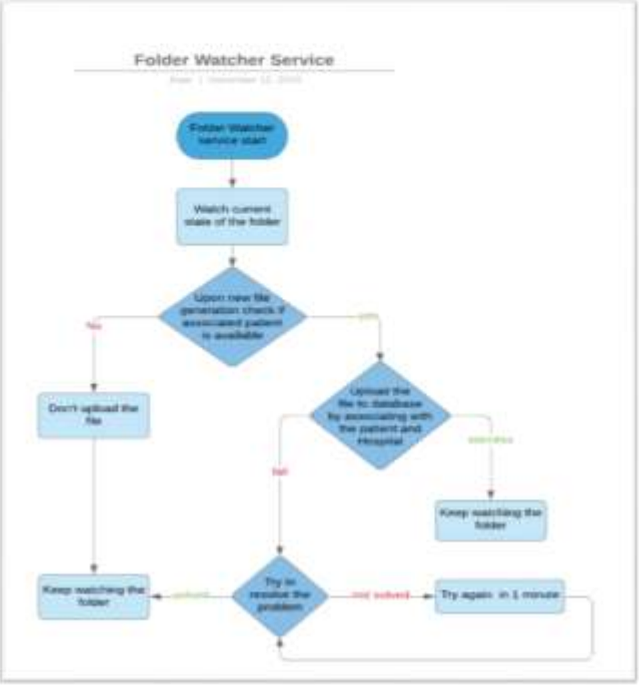
Folder Watcher Service
Folder Watcher service start
Watch current state of the folder
Upon new file generation check if associated patient is available
No
yes
Don't upload the file
Upload the file to database by associating with the patient and Hospital
fail
Keep watching the folder
Keep watching the folder
Try to resolve the problem
solved
not solved
Try again in 1 minute

Figure 3.20: Folder watcher service

For detecting the NID No we first tried to decode the barcode info and made an app regarding this, GitHub link is given below,
GitHub Link: https://github.com/afmjoaa/NID_Scanner

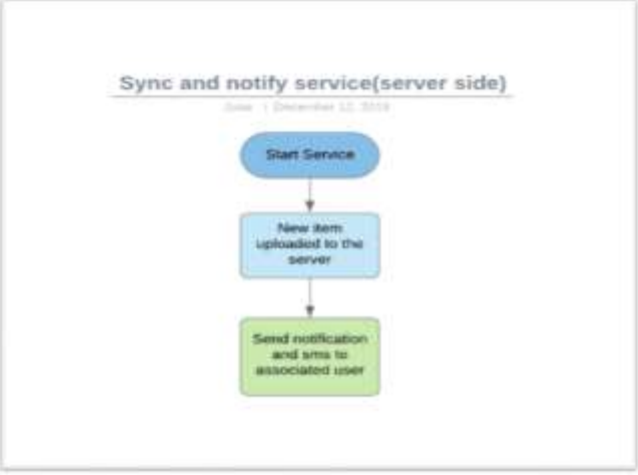
Sync and notify service(server side)
Start Service
New item uploaded to the server
Send notification and sms to associated user

Figure 3.21: Sync and notify service (server-side)

But we found this method of detecting NID very unreliable so we tried another way,
In the second approach, we tried OCR to detect the NID card info.
And found a much more reliable detection rate

G. *Connect to Database:*

For the database, options such as MySQL, PostgreSQL, Mongo DB, and Firebase were explored. Firebase emerged as the ideal choice due to its easily scalable real-time NoSQL database and additional services. The decision was influenced by Firebase's real-time capabilities, scalability, robust security rules, and the backing of Google. The focus of this step was primarily on integrating the database with the uploader and presenter components of the project.

H. *Debug and Alpha Release:*

At last, we have extensively debugged the software for errors and then generated the Alpha release for the E-Med uploader & and E-Med Presenter.

IV. RESULT AND DISCUSSION

As for the abstract idea, we have made two software for prototypes those are the following.

A. *E-Med Uploader::*

In the E-Med Uploader, we try to make patient identification and report delivery automated upon report generation from the hospital. For the identification, we used five methods those are the following,

- Fingerprint (Right Index, Right thumb, Left Index, Left Thumb)
- NID Scan
- NID Number
- By Email
- By Phone

The figure of the home page of E-Med Uploader is given below:

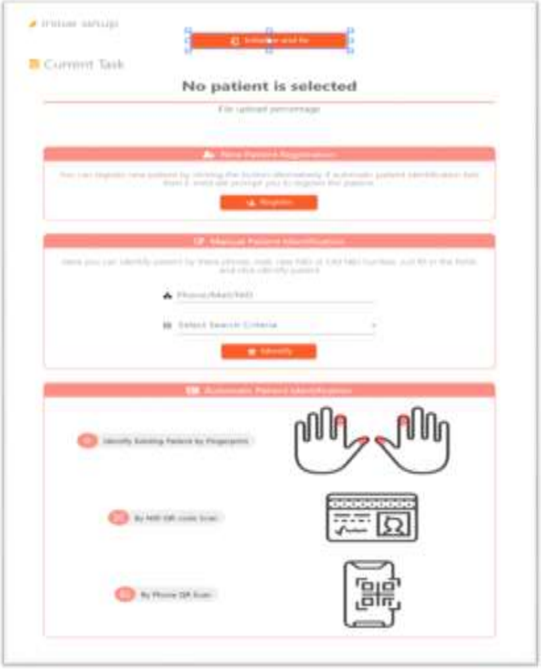

Figure 4.1: E-Med Uploader home page

The E-Med uploader awaits report generation by imaging/diagnostic modalities, then uploads the file to the database, associating it with the patient and hospital. This system can be adapted for pathology lab reports. Patient registration checks for reuse of email, phone, NID, or fingerprint. Generated reports and prescriptions are automatically uploaded to the patient app, ensuring up-to-date medical records. The system allows modifications and maintains a chronological record. Ethical considerations restrict unauthorized report modifications. Authorized hospital agents adhere strictly to rules, with legal actions for violations. De-identified data safeguards patient privacy by removing personal information following scientific and statistical principles.

B. E-Med Patient:

E-Med Patient is a demo Android app, "E-Med Patient Alpha," available on the Google Play Store. The app enables registration for Bangladeshi citizens using NID, phone, and email. Users can log in, schedule doctor appointments, access medical reports, receive health insights, and engage in health discussions. Appointment schedules, medical reports, and prescriptions are automatically uploaded, and the app provides reminders. Hospitals can identify users using the app's QR code scanning feature.

Link to E-Med Patient Alpha on Google Play Store

The E-Med project, currently a prototype due to budget and time constraints, aims to evolve into a comprehensive medical database and E-health communication system. Focused on gradually expanding to serve multiple hospitals, it plans to integrate various medical devices for instant report generation. Features include a drug database, patient medical assistant, and more. In comparison to existing EHR/EMR solutions like DHIS, OpenMRS, and OpenEMR, E-Med distinguishes itself as an online report delivery system to simplify healthcare processes, offer doctor and patient companionship, and optimize workflows without replacing doctors

V. CONCLUSION

The thesis presents an automated online report delivery system, utilizing fingerprints, email, phone, or NID for patient identification. Acknowledges technology's role in healthcare, emphasizing future development, metadata utilization, and adherence to de-identification protocols for privacy in large health datasets.

current E-Med system has certain limitations that could be addressed with future improvements:

System Maturity: The system requires time and usage to mature, emphasizing the need for training opportunities.

Fingerprint Authentication: Currently unable to store fingerprints in the database, relying on the government NID database for fingerprint authentication.

Payment Integration: Integration of a payment system is suggested to enhance the user experience.

Hospital Information System: Consideration for the integration of a comprehensive hospital information system for a more holistic approach.

REFERENCES

[1] E-Health, Telehalth, and Telemedicine. (2002). Wiley.

[2] Stowe, S. and Harding, S. (2010). Telecare, telehealth, and telemedicine. *European Geriatric Medicine*, 1(3), pp.193-197.

[3] White, F. (2015). Primary Health Care and Public Health: Foundations of Universal Health Systems. *Medical Principles and Practice*, 24(2), pp.103-116.

[4] Wendt, C., Frisina, L. and Rothgang, H. (2009). Healthcare System Types: A Conceptual Framework for Comparison. *Social Policy & Administration*, 43(1), pp.70-90.

[5] Ren, Y., Werner, R., Pazzi, N. and Boukerche, A. (2010). Monitoring patients via a secure and mobile healthcare system. *IEEE Wireless Communications*, 17(1), pp.59-65.

[6] Lafky, D. and Horan, T. (2011). Personal health records. *Health Informatics Journal*, 17(1), pp.63-71.

[7] Evans, J.A., Macneal Memorial Hospital Assoc, 2002. *Electronic medical records system*. U.S. Patent 6,347,329.

[8] En.wikipedia.org. (2019). *Medical record*. [online] Available at: https://en.wikipedia.org/wiki/Medical_records [Accessed 14 Dec. 2019].

[9] Docs.microsoft.com. (2019). *What is WPF? - Visual Studio*. [online] Available at: https://docs.microsoft.com/en-us/visualstudio/designers/getting-started-with-wpf?view=vs-2019 [Accessed 12 Dec. 2019].

[10] Utzhanova, A. (2016). FINGERPRINT TECHNOLOGY AND SUSTAINABLE DEVELOPMENT. European Journal of Sustainable Development, 5(4).

[11] Lin, J. and Fuh, C. (2013). 2D Barcode Image Decoding. *Mathematical Problems in Engineering*, 2013, pp.1-10

[12] Docs.microsoft.com. (2019). *What is WPF? - Visual Studio*. [online] Available at: https://docs.microsoft.com/en-us/visualstudio/designers/getting-started-with-wpf?view=vs-2019 [Accessed 12 Dec. 2019].

[13] En.wikipedia.org. (2019). *Flutter (software)*. [online] Available at: https://en.wikipedia.org/wiki/Flutter_(software) [Accessed 12 Dec. 2019].

[14] En.wikipedia.org. (2019). *PyQt*. [online] Available at: https://en.wikipedia.org/wiki/PyQt [Accessed 12 Dec. 2019].

[15] Quora.com. (2019). *What is a mobile native app? - Quora*. [online] Available at: https://www.quora.com/What-is-a-mobile-native-app [Accessed 12 Dec. 2019].

[16] En.wikipedia.org. (2019). *Adobe XD*. [online] Available at: https://en.wikipedia.org/wiki/Adobe_XD [Accessed 14 Dec. 2019].

[17] Quora.com. (2019). *What is the use of Adobe XD? - Quora*. [online] Available at: https://www.quora.com/What-is-the-use-of-Adobe-XD [Accessed 14 Dec. 2019].